Usability Analysis of Smartphone Applications for Drivers

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Abstract. This article shows the results of a benchmarking conducted of four different GPS navigation apps intended to be used while driving. The analysis was based on usability guidelines for smartphones and safety guidelines for the use of in-vehicle information systems (IVIS). The analysis aimed to observe and compare the main issues and solutions related to the use of these apps in a very particular context of use (driving a vehicle). The results demonstrate that, although there are some good interface solutions, there are potentially dangerous issues to a specific context of use that can lead to driver distraction.

Keywords: GPS app design, usability, driver distraction.

1 Introduction

It's not surprising that the use of smartphones is in vogue in the communication market. Since 2008, with the arrival of the iPhone and its revolution in the model of interaction with the mobile platform, the development in this area has grown wildly. According to statistics from a survey conducted by Google in partnership with Ipsos Institute [1], in just one year, the number of smartphones in Brazil has nearly duplicated - from 14% in 2012 to 26% in 2013.

This boom of sales was accompanied by a significant increase of the number of applications available in the major App Stores (Apple App Store, Google Play, Windows Phone Store and Blackberry World). However, the development of this area and sale's growth do not necessarily mean product quality in terms of interface design.

Nowadays, there are several smartphone apps designed to be used while driving, to guide the driver along the way he should go or for give information about the traffic jams, or warn about the events that are occurring in traffic (such as accidents, constructions, etc.), and many other services. It can be seen that, day after day, new applications are being developed for use in vehicles.

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2 Problem

As can be seen in most GPS navigation apps available in the App Stores, much of the information presented on displays has small size to be read while driving, even more considering vehicle's vibration. Other issues, such as the visual demand required for the completion of data entry tasks and the lack of standardization and compatibility with the user expectation and with operating systems seem to be problematic [2], as well as the number of actions needed to interact with the application while driving. All these problems can lead to potential driver distractions, impairing road safety.

According to the U.S. National Highway Traffic Safety Administration [3], driver distraction can be defined as "a specific type of inattention that occurs when drivers divert their attention that occurs when drivers divert their attention away from the driving task to focus on another activity". This distraction can occur in different ways, according to the following categories:

Visual Distraction – Task that require the driver to look away from the roadway to visually obtain information (like app's visual interfaces);

Manual Distraction – Tasks that require the driver to take a hand off the steering wheel and manipulate the device(Like the data entry by touchscreens and physical buttons);

Cognitive Distraction – Tasks that require the driver to avert their mental attention away from the driving task.

Burns [4] points out that both multifunction devices (products with multiple functions on a single display with few controls) or portable technologies most often overlook the user's needs, capabilities and limitations, preventing the effective integration between the system and the user. The author believes that mobile devices can become the road safety's biggest problem.

Due to its portability and the fact that a smartphone can be used in any situation or location, they can't be disconnected from the context of use, which means that very often users don´t have time or appropriate environment to perform certain tasks, requiring a system adequacy to the context in which it will be used. Further, Clark [5] and Wroblewski [6] also argue that the experience of using a mobile device is similar to operate any device with one hand and one eye seeing a big blur, which means that distractions are very constant during the interaction and, in most of cases, users don't pay attention to details.

Despite the different possibilities of use and scenarios, many authors [11, 8, 5, 9, 10, 6] affirm that due to the difficulty to interact with small screens, low processing speed, high effort to navigate on smartphones, the tasks performed with them should be as brief, focused and simple as possible. For the authors, much of the usability issues found in apps are closely related to hardware limitations. Such limitations impose themselves during the apps' development stages being definitive factors for the choice of the interface elements.

When smartphones are used outdoors, there are many factors that impair the interaction with the interface, both directly and indirectly. Common examples are: the display glare due the sunlight or the distraction caused by the driving task.

Wroblewski [6] states that good apps should be prepared to the interaction in the real world, considering their actual context of use since users are not locked in rooms reserved for doing certain task.

3 Methodology

This study aimed to conduct a comparative analysis (benchmarking) of some the most popular GPS navigation systems in Brazil based on usability guidelines for mobile devices and guidelines for the driver's safety with the use of in-vehicle information systems (IVIS). The chosen applications were: a) TomTom Brazil, b) iGO Primo Brazil, c) Sygic Brazil and d) Waze (navigation function).

For the analysis the following methodology was used:

1. Extensive literature review of books on usability in mobile interfaces [5-8, 10, 11], aiming to collect for principles and design guidelines;
2. Literature review of governmental documents and notices, and reports and books on recommendations for IVIS [3, 12-16], also with the purpose of gathering standards and guidelines on road safety;
3. Collection of guidelines for the development of mobile applications from human interface design guides [17-20];
4. Analysis and consolidation of all emerging guidelines from the literature review and guides, using a bottom-up approach like the Affinity Diagram [21];
5. Benchmarking of the applications based on the consolidated guidelines.

3.1 Consolidation of Emerging Guidelines for Smartphones Apps for Drivers

Due to the large amount of information collected in the literature review, a specific tabulation was needed to enable a direct analysis of similar guidelines from different sources – for example, comparing the two publications that talk about the navigation in menus. Also, because of the discrepancy between the subcategories defined by different sources and together with the amount of data (many of them with the same information), the Affinity Diagram was chosen as the most suitable technique, from a bottom-up approach.

The Affinity Diagram technique is a fast and efficient activity for treatment of a large amount of information, with the basic purpose of grouping similar items. For Barnum [21], the technique consists of a series of steps, which should preferably be performed in group, such as: 1) collect information and write them on sticky notes; 2) put all of the sticky notes up on a wall or whiteboard in random order; 3) organize the sticky notes by grouping the ones that are somehow related or similar – preferably without dialogue among the team; 4) when the grouping has finished, team members must label the categories of each group of sticky notes; 5) With labeled groups, they should be placed in a logical hierarchy, subjecting one group to another, if relevant, or dividing them.

For a better understanding, initially each guideline was selected according to the table of usability principles developed by Quaresma [22]. Once the guidelines were selected by principles, the sticky notes were regrouped into groups of thematically similar subjects – like for example, navigation or inputs by gestures; and then a hierarchy of themes was made by subdividing larger groups and subordinating smaller groups. Finally, the guidelines were consolidated in groups by the union of those that had recurrent content between the different sources.

The process to consolidate the emerging guidelines was conducted in three stages. In the first stage, all guidelines from books on usability in mobile interfaces and human interface design guides were grouped. In the second stage, driver safety guidelines for the use of IVIS were grouped too. In the final stage, the two groups were merged, considering the proximity and adaptation of content.

3.2 Definition Criteria for Apps Analysis

For the apps comparative analysis a table was created with categories of guidelines defined in the consolidation (Table 1), which were used as criteria to analyze and compare screen by screen of each application. It was highlighted both the items that don´t meet the criteria, as well as positive items that exceed the expectations regarding the guidelines' rules.

Table 1. Guidelines categories used as criteria for apps analysis

Guideline Categories	Description
1. Context	Guidelines that focus on the environment, circumstance and the way the users interact with their smartphones, taking into account the basis of mobility principles;
2. Content	Guidelines focused on selecting the information to be presented in a mobile platform, considering the importance, volume and adaptation of information and its presentation timing;
3.Information Architecture	Guidelines related to the general structure of an application and organization of its content, following the major systems of information architecture – organization, navigation, labeling and search;
4. Screen Layout	Guidelines related to screens setup, layout of graphical and textual elements on the screen and their adaptations to the screen sizes;
5. Maps	Guidelines related to the use of maps displayed for geolocation and other purposes;
6. Charts	Guidelines focused on recommendations for the use of charts;
7. Forms	Guidelines concerning the use of forms in the mobile platform;
8. Dialogs	Guidelines regarding the communication outputted by the system to the user;
9. Entry Methods	Guidelines related to user's inputs and his interaction with graphic elements, considering the tools of data entry, such as keyboards, gestures or several sensors;
10. System Functions	Guidelines concerning specific tools and issues of mobile context, such as autosave or integrated devices - GPS, camera and accelerometer.

4 Results

The applications were compared based on the main sections of driver interaction while driving: route guides (maps), main menu and address data entry. Thus, the conclusions could be drawn about the interfaces design, considering well designed solutions, isolated failures and problems in common.

4.1 Route Guides

In this section, the main issues found were about the clarity of the information on the map, the quality of interaction with it, the legibility of icons, navigation and map shortcuts. When comparing the clarity of the map information of the four applications, it is evident that the systems (a) and (d) show maps and information more efficiently (Fig. 1 and Fig. 4), due to their simplicity and their care with the amount of graphic elements. Noteworthy the system (d) that uses well placed transparencies so that the elements do not interfere with information about the route, keeping the driver's attention on the main information (Fig. 4). In contrast, the system (c) presents a complex and confusing screen, without a proper indication of interaction elements (Fig. 3).

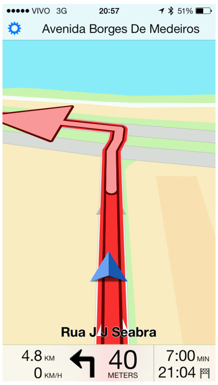

Fig. 1. Route Guide, System (a)

Fig. 2. Route Guide, System (b)

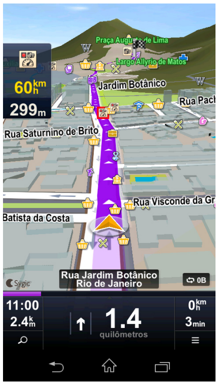

Fig. 3. Route Guide, System (c)

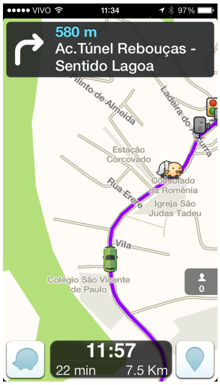

Fig. 4. Route Guide, System (d)

Regard to the interaction with the map, it is noticeable that all four systems have issues regarding recognition of the interaction elements. Systems (a) and (d) present issues for novice users, due to the fact that the system (a) does not use navigation affordances to find the main menu, requiring a direct tap on the map. The button to access the main menu of system (d) shows an unclear icon for those unfamiliar with the app visual identity (Fig. 4). The main issue with system (b) in this point is related to an inconsistency in button icons, since they vary according to what is selected in the main menu – basic, custom or full menu (Fig. 2 and Fig. 11). While the system (c) presents an issue due the difficulty to distinguish the elements of interaction from the route guide information (Fig. 3).

As for the legibility of icons, the system (d) stands out from others by having map icons well designed, ensuring good legibility during interactions (Fig. 4). This becomes clear when compared to the system (c), which has exactly legibility issues considering the size and design of its icons. These issues may impair the system comprehensibility (Fig. 3).

In the category map navigation, the systems present a very similar operation, allowing a pan view on the map and offering a button to return to the vehicle position – except system (a), which for security reasons does not allow this type of functionality (pan view interaction) in the route guide. The main difference between them is that the system (d), unlike the others (Fig .5 and Fig. 7), has a button with a target icon to return to the point of view to vehicle location on the route (Fig. 9), symbol very common in this type of application.

Fig. 5. Map Navigation, System (c)

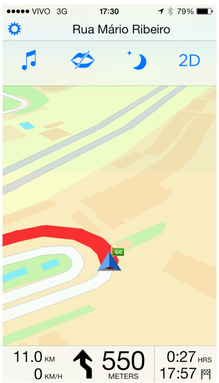

Fig. 6. Map shortcuts, System (a)

Fig. 7. Map shortcuts, System (b)

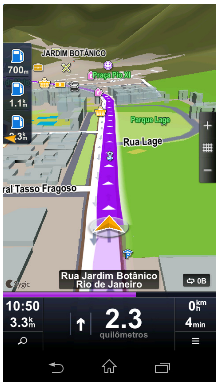

Fig. 8. Map shortcuts, System (c)

Fig. 9. Map shortcut, System (d)

Finally, analyzing the shortcuts on the maps, as can be seen most applications underuse this tool, offering very basic functions for map interaction, like pan view, zoom and compass (Fig. 7-9). Only system (a) offers shortcuts with really relevant functions that need quick access – music functions, mute switch, day/night colors and 2D/3D vision (Fig. 6).

4.2 Main Menu

In this section, the issues found are directly related to the amount of menu options and the way it is presented to the user, taking into account the information architecture and screen layout.

In terms of amount of menu options, the applications offers between 5 and 8 options per screen, thereby minimizing the use of scroll and keeping the good standards of usability. The only ones that differ from this pattern are the system (d), displaying four options (Fig. 13) – since it is not classified as an advanced GPS system, and system (b) with a total of 28 options in the full menu, providing several unnecessary options competing with the driving task. Even though the latter system provides two other types of menu – basic and custom (Fig. 11), interfaces designed for the interaction while driving must not allow the user to deal with so many options. This kind of issue forces the driver to spend precious time scrolling to find what he is searching.

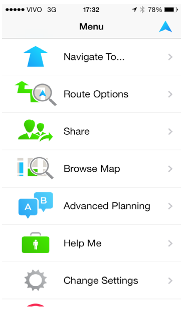

Fig. 10. Main Menu, System (a)

Fig. 11. Main Menu, System (b)

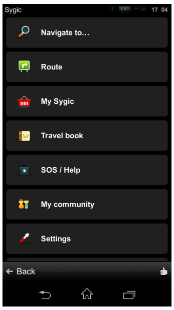

Fig. 12. Main Menu, System (c)

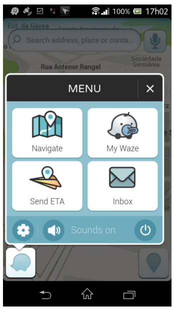

Fig. 13. Main Menu, System (d)

In terms of menu layout, the systems have adopted two different ways to present the information: springboard menus – used by systems (d) and (b) (Fig. 11 and Fig. 13), and the list menus – used by systems (a) and (c) (Fig. 10 and Fig. 12). However, only (a) and (d) have made better use of the chosen type of menu, adapting themselves to their different needs, handling well with the icons size and ensuring good text legibility (Fig. 10 and Fig. 13). These factors were not correctly handled by the other two, once the system (c) does not fill all the available space of the cells (using small characters) (Fig. 12) and (b) uses two lines of text in its cells, having to reduce the size of the icons without using a consistent pattern for the system (Fig. 11).

The last point of this section is related to the quick access of the route guide for times of emergency. The analysis concluded that only the systems (a) and (d) have a shortcut that allows direct access to the of the route guide at any point in system hierarchy (Fig. 10 and Fig. 13). The others require the user to use the back button several times until he can reach the map, which can be harmful if a maneuver information is required (Fig. 11 and Fig. 12), beyond the fact that this can become the interaction unnecessarily harder.

4.3 Address Data Entry

For this section the issues observed were mainly related to the process of the task completion and the adaptation of the data entry methods to the user's needs.

As for the process of address data entry, this is a very hard task for any driver to perform with the vehicle in motion. Good solutions are associated to lower amount of interactions that the user must perform to achieve his goal (entering the address). Although systems do not have a significant difference, the systems (a) and (d) have a shorter process in terms of the amount of screens to interact for data entry. These systems suppress unnecessary screens and information to the user, such as the screen of the selected target presented by the system (b) (Fig. 14) or the screen for choosing between "Drive to" or "Walk there" requested by the system (c) (Fig. 15).

Fig. 14. Destination point view, System (b)

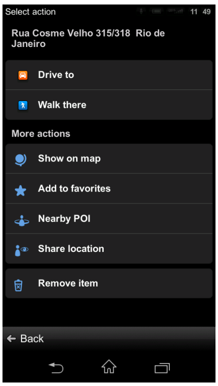

Fig. 15. Select Action Screen, System (c)

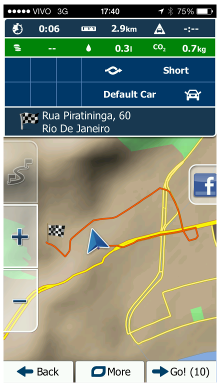

Fig. 16. Route information System (b)

Finally, about the methods of data entry, most apps use the default keyboard system, with the exception of (b), which uses proprietary keyboard due to its dynamic search filter. Although they use similar systems, the apps consider users' needs in different ways. A well-executed solution was observed in the system (b), with its dynamic filtering of possible keys related to the text being written, limiting the choice of characters to be typed (Fig. 19-20). Another good example is the fact of system (a) changes the keyboard to a numeric system similar to a phone keyboard (Fig. 18), making it easier to entry the address numbers. The applications (d) and (c) are flawed in this aspect due to the fact of not having predictive text (Fig. 23) and not clearing the fields after an address data entry (Fig. 21-22), respectively. In system (d) the task of address data entry is even harder, once that the user needs to type the full address to be found in the system database (Fig. 23-24), which means a waste of time and great effort while driving.

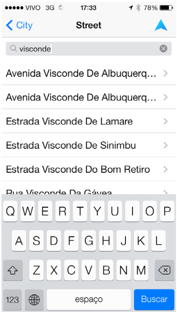

Fig. 17. Street Name Entry Screen, System (a)

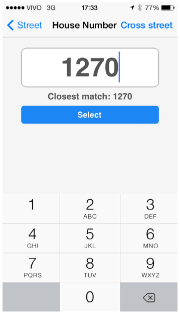

Fig. 18. Street Number Entry Screen, System (a)

Fig. 19. Custom keyboard, System (b)

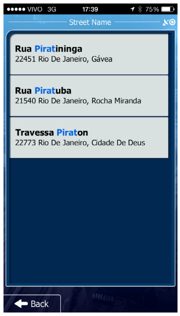

Fig. 20. Address Selection Screen, System (b)

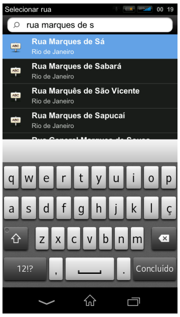

Fig. 21. Street Name Entry Screen, System (c)

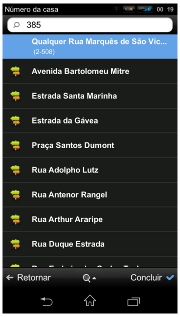

Fig. 22. Street Number Entry Screen, System (c)

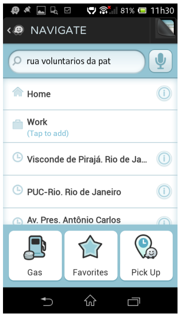

Fig. 23. Address Data Entry Screen, System (d)

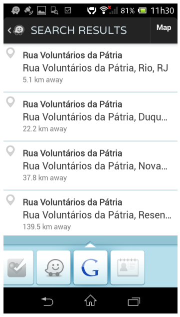

Fig. 24. Address Selection Screen, System (d)

5 Conclusions

It is a fact that the growth of the smartphone market, combined with an improvement of the input data and geolocation technologies, provides a development of applications targeted for use in vehicles. The main issue is that this kind of application can distract the driver instead of help him during driving task, once the context of use and the design principles are not considered in its conception.

This research aimed to conduct benchmarking with four applications for drivers that work as GPS navigation systems – TomTom, iGO Primo, Sygic, and Waze, considering the usability guidelines for smartphones and those for safety in use of

IVIS. This study presents some usability and safety issues found in each application and their consequences when compared to other solutions that better attends user needs. The research concluded that even if the systems are not dedicated for driving context, it is important to minimize the effort for both comprehension and performing of the tasks. This way, it is possible to design better interfaces and more adapted to deal with the challenges inherent in driving context.

This research is part of an ongoing study on usability of smartphones applications developed for use in vehicle. The next steps intends to make similar studies with other categories of applications for drivers, in order to investigate the issues that impair the driving task and reach a consensus on recommendations of safety and usability for this type of application and interaction (driver-smartphone).

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